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An econometric decision model for equalizing regional unemployment in West and East Germany

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Abstract

Reducing disparities among regions within European countries is the aim of European and national structural policies. In particular, a European grant contributes to the German governmental program for equalizing regional unemployment. The goal is to bring it down to the national average by creating new and/or by safeguarding existing jobs.

In the given paper the distribution of available aid among 271 German labor market regions is considered as an econometric decision problem. At first, the dependence of the unemployment rate on the amount of aid is estimated for each eligible region. Using this dependence, the variance of regional unemployment rates is expressed as a function of the regional subsidies. The optimal aid distribution among regions is obtained by minimizing this variance subject to the total budget constraint and administrative restrictions.

The optimal figures computed are compared with statistical data for 2000–2002. They show that the regional unemployment in West Germany could be equalized better (with variance 3.50 against the actual 4.40) and with a simultaneous decrease in the average unemployment in West Germany from 7.45 to 7.28%. In East Germany all regions are eligible, implying no administrative constraints and a high optimization flexibility. It enables almost perfectly equalize regional indices down to the variance 0.28 against the actual 9.76.

Under the model assumptions, the actual results of the equalizing policy could be attained by half the budget granted. These underused possibilities explain the low efficiency of active labor market policies reported in empirical studies. To improve their performance, some tools for optimally distributing subsidies and predicting their effects are suggested.

Keywords: European Commission, structural fund grants, regional policy, equalizing regional unemployment rates, econometric optimization model.

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Chapter 1

Introduction

1.1 Regional unemployment

The regional unemployment rate is one of most important indicators of socio-economical equilibrium. Besides, it characterizes the regional governmental performance and serves as a governmental assistance criterion. Its equalization all over the country is expected to improve the national output and to decrease the inflation pressure (Taylor 1996).

According to Fothergill (2001) and Elhorst (2003), the unemployment disparity among regions within countries is becoming a source of troubles in the European Union. They are getting comparable with that among the countries themselves (Elhorst 1995, Taylor and Bradley 1997, European Commission 1999). The extension of the European Union to the East, where the economical imbalance is aggravated by transition processes, makes this problem even more acute.

Compared with the unemployment at national and intra-national levels, the regional unemployment is relatively little studied. The 3630 page *Handbook of Labor Economics* (Ashenfelter and Layard 1986, Ashenfelter and Card 1999) contains nothing on regional unemployment, and the *Handbook of Regional and Urban Economics* contains just a half-relevant chapter on urban unemployment (Crampton 1999). All of this illustrates how far the topic is from the mainstream research.

The belief that the nature of regional unemployment is similar to that of unemployment in general is rather superficial. The factors which are thought to explain disparities among countries (e.g., Phelps 1994, Malinvaud 1994, Bean 1994, OECD 1994, Scarpetta 1996), like institutions of wage bargaining, social security, retirement, and taxes are not relevant to regions. Indeed, they differ between countries but not between regions within countries; consequently some other factors should exist.

Elhorst (2003) has reviewed 41 empirical studies, where regional unemployment differentials are explained with the help of regional data. These models (some are not implemented in formulas) are classified as follows:

1. **Single equation models** (one independent and one dependent variable):

   (a) *empirical models*, mostly with no equations but nevertheless suggesting factors which might be used as explanatory variables,

(b) *the inverse unemployment-vacancy relationship*, or the Beveridge curve (e.g., Jones and Manning 1992, Holzer 1993),

(c) *the cyclical sensitivity model* which explains the regional unemployment as a linear function of the national unemployment; such a model makes sense if the regional and national unemployment *cointegrate* in the sense of Engle and Granger (1987) into an equilibrium configuration (e.g., Chapman 1991, Martin 1997, Baddeley et al. 1998),

(d) *the amenity model* which explains the regional unemployment as a function of aggregated attractiveness of the regions, for instance, reflected by the wage-to-infrastructure-index ratio (e.g., Marston 1985, Montgomery 1993).

2. **Implicit models**

(a) *the migration-based model* which explains the regional unemployment by migration flows (e.g., Molho 1995, Groenewold 1997),

(b) *the NAIRU model* (= non-accelerating inflation rates of unemployment), or the Phillips and wage-setting curves (e.g., Jones and Hyclak 1989, Payne 1995),

(c) *the Blanchard–Katz model* (1992) with four equations which links the regional unemployment rate to labor supply, labor demand, wage-setting, and migration of both population and firms; a similar study on the regional unemployment in the European Union is performed by Decressin and Fatás (1995).

3. **The accounting identity models** which are based on estimating the impact of a single individual, depending on his identification either as a local unemployed, or migrant, in-commuter, or out-commuter, etc. (e.g., Gordijn and Wissen 1992, Wissen and Ekamper 1995).

4. **The simultaneous models with interactions**, which take into account the feedback of the regional unemployment to the explanatory labor market variables, like the labor force participation rate, degree of employment and earnings, labor demand, etc. (e.g., Bilger et al. 1991, Blanchard and Katz 1992, Blackaby and Manning 1992, Decressin and Fatás 1995).

As concluded by Elhorst, the models reviewed provide clear-cut trends in the interaction between the regional unemployment and other labor market variables. It should be noted however that these models directly or indirectly assume a kind of labor market equilibrium, which is a certain idealization. The factors which violate the equilibrium, like governmental creation of new jobs, are not explicitly taken into account.

1.2 Active labor market policies

Active labor market policies are aimed at reducing unemployment and are implemented in all developed countries (Fay 1996, Heckman et al. 1999, Martin 2000, Steiner and Hagen 2002). They fall into three main schemes.

1. *Job creation* is offering subsidies to wages mainly for short-running projects in non-profit organizations. These jobs are often given to former long-term unemployed and are usually restricted to terms of about one year.

2. *Structural adjustments* is also offering wage subsidies but with other goals and in a closer collaboration with private firms. The subsidies are aimed at integrating the employees into the main activities and are given for terms of about three years.

3. *Public training* is a number of educational measures paid by the employment office. They are aimed at improving the chances for employment and increasing the employment stability.

According to Bundesanstalt für Arbeit (2003b), during the period of 1990–2002 only in East Germany 6.5 Mio workers, which is about the number of active employees, were involved in these programs with the overall budget 138 billion EURO. Expenditures of such a range require systematic analysis of their effects.

Microeconomic studies are based on comparisons between groups of participants and groups of non-participants; for surveys see Hagen and Steiner (2000) and Hujer and Caliendo (2001). As follows from these surveys, there is no clear evidence of either positive, or negative effects of the German active labor market policies on the future prospects of the participants. This indefiniteness has been also confirmed by the recent report based on large administrative data (Hujer et al. 2003).

Hagen (2003) criticizes the microeconomic approach for its *stable unit treatment value assumption* (Rubin 1980). In the given context it means that the control groups of non-participants are not affected by the programs. Since the programs are very extensive, their indirect effects on the non-participants are likely to be quite significant. It implies a violation of the basic assumption, making questionable the microeconomic investigations.

The macroeconomic approach, on the contrary, assumes simultaneity and reciprocal influence of all factors within the economy. Several authors selected it as more appropriate for estimating the indirect and *net* effects of active labor market policies (Heckman et al. 1999). However, the macroeconomic studies based on regional data reveal no unambiguous trends either (Büttner and Pray 1998, Steiner et al. 1998, Hagen and Steiner 2000, Schmid et al. 2001, Blien et al. 2002, Fertig et al. 2002, Hagen 2003).

In the most recent study Hagen (2003) applied three macroeconomic approaches to East German regional data:

- an augmented matching function approach which evaluates the effects of the active labor market policies on regional matching efficiency,

- a reduced-form approach based on the Beveridge curve which assesses the effects on the regional job seeker rate, including both unemployed and participants in the active labor market policies,

- a regional labor demand approach.

The main finding was a certain negative effect of job creation and no significant effect of structural adjustments and of public training on the regional employment. In spite of having used alternative approaches, a number of questions remained open.

It should be noticed that both micro- and macro- modelling do not take into account such general factors as accelerating technological transformations with new requirements to the employees, support of Eastern Europe and globalization which channelled financial flows out of developed countries and moved some industries and services to the Third World, and the recession which started in Asia in the mid-1990s and then expanded to the West. Their negative implications can mask the positive effect of the active labor market policies, without which the labor market situation might become much worse.

1.3 Unemployment and optimization

The point left with little attention is the quality of realizing governmental programs. According to Lechner and Smith (2003), "caseworkers do not do a very good job of allocating their unemployed clients to the subprograms so as to maximize their subsequent employment prospects." It can imply that not the policies intended but their implementation is responsible for their low efficiency reported in empirical studies. In a market economy, underused possibilities and a non-optimal behavior often cause redistributions and structural shifts which can lead away from the results expected. For instance, an imbalanced job creation causes migrations which reduce local effects.

Lechner and his colleagues (2003) took part in developing a statistical expert system which customizes the offer for each particular unemployed client. This may be the only instance of any kind of optimization approach in the vast research on active labor market policies. (In a personal communication Lechner was somewhat surprised to learn about my optimization interpretation of his work. Elhorst after having compiled a comprehensive survey was not aware of any optimization approach.)

Such a general neglect of optimization methods is amazing in two respects. The role which optimization plays in the modern economy is hard to overestimate (Samuelson 1971). As far as it concerns market relations, the (quasi) optimization is guided by 'the invisible hand', Adam Smith's (1776) metaphor for competition. This, however, is not the case in the public sector with central planning and budget governmental programs. Consequently, optimization should be primarily applied in the public sector and particularly in the domain discussed.

On the other hand, almost all quantitative studies on unemployment are essentially econometrical. Yet the founders of econometrics, the first winners of the Nobel Prize in economics (1969) Jan Tinbergen and Ragnar Frisch always linked econometrics to optimization. Among other things, both Tinbergen and Frisch were faced to unemployment problems and in the 1950s made pioneering contributions to econometric optimization models (Frisch 1963, Tinbergen 1952, 1956, see also Johansen 1974); this topic was selected by Frisch for his Nobel Address (1970). Consequently, there exist also historical prerequisites for interactions between unemployment studies, econometrics, and optimization.

How does it work in practice? To give an idea, imagine that we optimize unemployment vs. inflation within $0 \div 10\%$ by controlling inflation by the Central Bank's interest rate. The *operational space* is two dimensional, with axes being the unemployment rate U and the inflation rate I shown in Figure 1.1. (The direction of axes is inverted to keep the top-right direction of improvement as traditional in utility theory.)

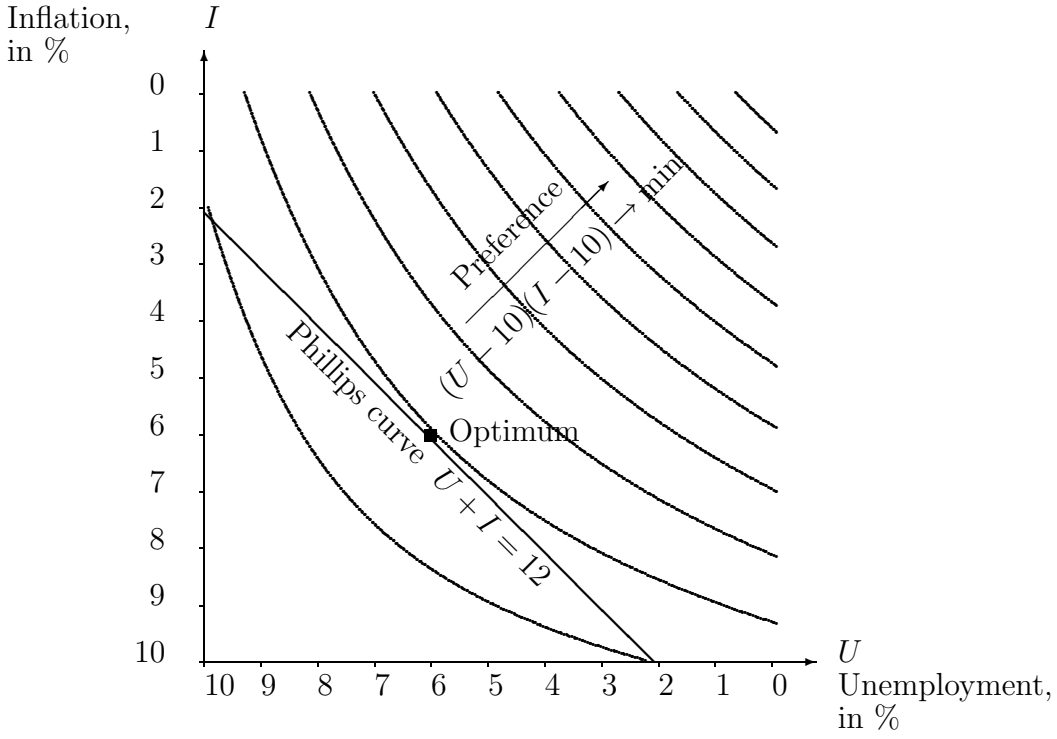


Figure 1.1: Econometric optimization model

Certainly, not every combination of indices in the plain Unemployment–Inflation is attainable. Econometrical methods based on statistical observations enable us to estimate the analytical relation between unemployment and inflation called the Phillips curve. In Figure 1.1 it is shown by the line $U + I = 12\%$. Thus an econometric model imposes a *constraint*, restricting the feasible domain.

Next a policy maker has to decide which combinations of indices are preferable. In real multidimensional situations it is not that easy and an *objective function* (= utility function) which takes greater values at better alternatives is defined.

Figure 1.1 depicts the map of the utility hill with *indifference curves*, along which the preference remains constant. They are level curves of the objective function $y = -(U - 10)(I - 10)$. Its values lie in the third dimension beyond the plane, determining the relief of the utility hill.

Finally the *optimal solution*, that is, the preferable combination of unemployment and inflation rates, is found as the highest utility point along the Phillips curve from the following optimization problem

$$\begin{array}{rlcl} \text{minimize} & (U-10)(I-10) & \Longleftrightarrow & \text{maximize} \quad -(U-10)(I-10) \\ \text{subject to} & U + I = 12 & & \\ & 0 \le U \le 10 & & \\ & 0 \le I \le 10 \ . & & \end{array}$$

In Figure 1.1 the optimum is attained at the point (6%, 6%) where the constraint line is tangential to an indifference curve. To attain the optimum, the Central Bank has to cause the 6%-inflation by appropriately adjusting the interest rate (for this purpose

another econometric estimation may be needed).

Summing up what has been said, the objective function represents the desired, the constraint derived from the econometric model represents the feasible, and their interaction results in the optimal decision. Thus econometric equations can be regarded as constraints in optimization models. In a sense, optimization adds an active element, the choice, to descriptive econometric models, making the next step in controlling the situation.

1.4 Econometric decision models

Just this philosophy was developed by R. Frisch and J. Tinbergen. For the first time, the term 'decision model' (= econometric optimization model) was used in Frisch's work for the United Nations Economic and Employment Commission in 1949 (Bjerkholt and Strøm 2002). This work was published as late as in 1955 and the idea of decision models became popular owing to Tinbergen's *On the Theory of Economic Policy* (1952) where he acknowledged Frisch's priority. Both Tinbergen and Frisch strongly promoted the so-called quadratic-linear approach with a quadratic objective function maximized or minimized subject to linear constraints.

The bottle-neck was the objective function, and Frisch (1957, 1971) suggested the *Multiplex Method* to construct it from interviews. In the mid-1950s he conducted "well planned interviews" with the Norwegian Minister of Finance Trygve Bratteli who became Prime Minister for the Labour Party in the early 1970s. Later this approach was tentatively used by Van Eijk and Sandee (1959), Chossudovsky (1972a–b), Van der Geest (1977), Merkies and Nijman (1983), Van Daal and Merkies (1984), Merkies and Hofkies (1991), Hüsges and Gruber (1991), and Medelin, Aspedale and Pachio (1994).

Frisch intended objective functions for decision models, but these plans had few successors. Frisch's ideas were not really elaborated but only discussed by Hallet and Rees (1983), Rustem and Velupillai (1984), Hughes Hallet (1991), and some others. In particular, Oswald (1985) explained perspectives of using econometric decision models for the wage formation. Recovering objective functions of trade union leaders and of leaders of employer's associations were supposed to imply the tradeoff between wage level and unemployment.

Tinbergen payed a considerable attention to econometric decision models but was inclined to derive the objective function from the formulation of the problem rather than from interviews (Kol and de Wolf 1993). Many of his objective functions are linear, but some are quadratic. It is the case of the model with fixed targets (= the ideal combination of variables), where the distance to the given point is minimized (Tinbergen 1956).[1] Tinbergen's approach was further developed by Theil (1964), Fox et al. (1966), Chow (1975) and other leading economists.

Tinbergen's view at econometric decision models was 'more objectivistic' than that of Frisch. Deriving objective functions from sources other than interviews looked more impartial and 'scientific'. Sharing this standpoint, several authors revealed objective func-

[1]Strictly speaking, it is difficult to avoid subjectivity even here. The distance in the econometric space is ill-defined. Axes are measured in different units like percent, absolute figures, dollar, or EURO. Determining their substitution rates brings the problem back to Frisch's interviews.

tions from panel data, in particular from tradeoffs observed. These studies are however not quite relevant to proper decision models, since they are not aimed at finding decisions but operate on the ones already made (like consumer choices). Moreover, a 'decision' is regarded as a kind of equilibrium-based optimization which is not exactly the subject of decision models. For a survey of related works see Dantzing at al. (1989a–b) where the objective function of the U.S. economy is constructed.

Tinbergen and his successors often considered abstract objective functions for analytical purposes, without numerically determining their coefficients. The linear-quadratic decision model which seemed quite operational was rather a theoretical framework. Persistent Frisch's efforts to develop methods for constructing objective functions were not more than practice-*oriented*. As concluded by Bjerkholt and Strøm (2002), "Frisch left this field of interest with work undone".

Gruber (2002) remembers that in 1965, after 35 years of existence of the Econometric Society and 16 years after the idea of econometric decision models had been introduced, he found no operational method for constructing objective functions. In both American and German dissertations Gruber (1965, 1967) had to use a heuristic quadratic objective function with no cross-products and roughly estimated coefficients of squared variables.

In subsequent years the situation did not improve much (Gruber 1979) and he tried to animate studies in econometric decision models by having organized four international conferences (Gruber 1983, 1991; Tangian and Gruber 1997, 2002). Interesting experiments were reported by Merkies; for the self-survey see Merkies (2002). A special method for constructing quadratic and additive objective functions was developed by Tangian (2001–2003a) and applied by Hilles and Tangian (2002), Schwarm (2002), and Teibach (2002).

Dealing with econometric decision models turned out to be more complex than initially expected. Compared with purely econometric models, they include an additional element, the objective function, and result in optimization problems to be solved. Unlike statistical methods applicable to almost all data sets, optimization techniques are not that universal. Respectively, econometric models are generally solvable but econometric decision models are not.

This makes building a decision model a kind of art. It assumes the knowledge of the subject domain. Selecting important factors, sorting out secondary ones, and formalizing ill-defined notions, relations, and preferences by variables, equalities, inequalities, and objective functions requires intuition and inventiveness. Configuring sophisticated optimization methods into a consistent model needs mathematical skills. Finally, the whole construct must be mathematically manageable and computable.

These claims explain why purely econometric models prevail over their optimization extensions. Another cause is the situation in mathematics and computer science. Statistics as a mathematical discipline was well developed before the invention of computers, and statistical packages became available already in the 1960–1970s. Optimization, or *mathematical programming*, was developed mainly after the Second World War just to meet new technical endeavors. Accordingly, optimization software was delayed, especially in the user-friendliness, by at least 20 years.

The last but not least cause of disregarding decision models in economics is the specificity of scholarly work itself. Statistics meets its habitual tasks of description, classification, analysis, and systematization. Decision making belongs to the competence of

engineers, managers, and policy makers. So a psychological factor is also present.

Summing up what has been said, econometric decision models are still in their infancy. Due to a delay in their development and other difficulties, they are much less used by scholars than purely econometric models. The latter are often sufficient as explaining the dependence of economic variables and thereby restricting the choice of economic policies to feasible ones. However, the policies restricted that way are still too numerous to make the final selection. For this purpose an operational objective function, which distinguishes a decision model, is required.

In particularly it is the case of active labor market policies. Econometric studies analyze their effects: short- and long-term employment, labor demand, migration, future prospects of participants, etc. It is recognized that labor market policies are implemented administratively with little use of optimization methods. Therefore, there is a hope that developing dedicated decision models can optimize them and improve their performance.

1.5 About the given work

Reducing disparities among regions within European countries is the aim of the European and national structural policy. In particular, a European grant contributes to the German governmental program for equalizing regional unemployment. The goal is to bring it down to the national average by creating new and/or by safeguarding existing jobs (Deutscher Bundestag 2002, Tetsch et al. 1996). It should be emphasized that this grant is given to *equalize* rather than to decrease the regional unemployment. The latter goal is subsidized from other sources.

The equalization of unemployment resembles the stabilization of an airplane. The stabilizer consumes some energy of the engine but is necessary to provide a safe flight. The equalization of unemployment takes some resources from the main budget of active labor market policies but prevents from structural disproportions. A limited grant naturally results in a trend to subsidize in the first turn the jobs which need less subsidies rather than the jobs which are 'expensive' for grant-givers. Since the 'price' of a job depends of prevailing regional industries and services, some regions are little supported and others, on the contrary, get too much aid. This decreases the average unemployment but increases the disparity among regions.

At present Germany is divided into 271 labor market regions, 204 in West Germany, and 67 in East Germany. The European employment policy restricts the regions to be supported to 23.4% of the total population (Crome and Schwengler 2000, Hassold and Jung 2000). Taking into account economic difficulties in East Germany, all its regions are eligible, and the budget is separate for West and East Germany. During the control period 2000–2002 all eligible regions received about six billion EURO; West Germany received 617.8 Mio, about 1/10, and East Germany — 5360.1 Mio, 9/10 of the total.

In the given paper we develop an econometric decision model for redistributing the aid among eligible regions in East and West Germany. The optimization is performed to equalize regional unemployment, according to the goals of European and national structural policies.

The modelling falls into the following steps.

- **Collecting data on regional unemployment in Germany**

  These data are available from Bundesamt für Wirtschaft und Ausfuhrkontrolle (2003), Bundesanstalt für Arbeit (2003a), and Statistisches Bundesamt (2003).

- **Explaining regional unemployment rates as functions in regional subsidies**

  Effects of active labor market policies on the regional unemployment have been outlined in Section 1.2. As revealed by Hagen (2003) and several other authors, the regional unemployment rates depend on the subsidies granted to the regions. For our study, we use the simplest linear estimation directly derived from the available statistical figures.

- **Operationalizing the criterion of regional unemployment disparity**

  For this purpose, the least variance of regional unemployment rates is appropriate. The variance measures the mean deviation of regional rates from the national average, exactly what is required to minimize.

  The criterion of least variance, not always explicitly, is used in models of market stabilization (Gruber 1965, 1967), general economic stabilization (Pindyck 1973, Friedman 1975), and optimal control (Chow 1975, Blanchard and Fischer 1989). For using objective functions in budget distribution problems see Fandel and Gal (2001) and Tangian (2003b).

- **Expressing the regional unemployment disparity in regional subsidies**

  To express the variance $\mathsf{V} = \mathsf{V}(\text{Regional unemployment rates})$ as a function of regional subsidies it suffices to replace the Regional unemployment rates in V by the linear functions estimated at the previous step:

$$\text{Regional unemployment rate} = A \cdot \text{Regional subsidy} + B \quad \rightarrow \quad \mathsf{V} \ .$$

  Since the variance is a quadratic function in its entries, this linear substitution results in a quadratic objective function in regional subsidies.

- **Building a decision model**

  It remains to impose the total budget constraint and to restrict the aid to the eligible regions. The problem operationalized that way is linear-quadratic, with the quadratic variance function minimized subject to a linear budget constraint and eligibility restrictions.

- **Solving the optimization problem**

  The linearly restricted quadratic programming problem is implemented in a computer program written in the MATLAB programming environment. For larger applications it might be possible to use the fast algorithm (Tangian 2001).

- **Analyzing the optimal solution**

  The equalization is performed for West Germany and East Germany with separate budgets. The figures computed are compared with the actual statistical data for 2000–2002. They show how to improve the distribution of European and national

grants among the eligible regions. In West Germany, the variance (of regional unemployment) can be reduced from the actual 4.40 to 3.50 with a simultaneous decrease in the average regional unemployment from the actual 7.45% to 7.28%. In East Germany all regions are eligible, implying no administrative constraints and a high optimization flexibility. It enables an almost perfect equalization of regional indices with the variance 0.28 against the actual 3.12.

If the total budget were not separated for East and West Germany, the overall equalization could be much better, with the variance 17.32 against the actual 27.29. Moreover, the average regional unemployment also decreases to 9.49% against the actual 10.11%. It would however require to redistribute the aid to East Germany and reduce the budget of West Germany to 110 Mio EURO against the actual 617 Mio.

Chapter 2, "Model", contains rigorous assumptions and mathematical propositions. The 'motor' of the model is the objective function, which operationalizes the idea of equalization. As often happens in new applications, an additional theoretical development is needed. In our case, we introduce the *variance operator* which reduces computing the variance to a vector/matrix multiplication, separates linear and quadratic operations, and thereby makes the optimization problem solvable.

Chapter 3, "Results", explains the model output represented by figures and tables. Then we comment on the recommended redistribution of the budget among the eligible regions. Next we suggest a tool for predicting the equalization effects of subsidies of variable size, which may be useful while planning a future equalization policy. Finally, we estimate the economic gain from using the model.

Under the model assumptions, the actual results of the equalizing policy could be attained by half the budget granted. These underused possibilities explain the low efficiency of active labor market policies reported in empirical studies.

The last chapter "Conclusion" outlines perspectives for further developments and recapitulates the main results of the paper.

Chapter 2

Model

2.1 Idea

Imagine 20 pipes of different profiles with different levels of water. Imagine that we have to refill some 'eligible' pipes with totally 10 liter water to the end of equalizing the levels. Since some pipes are larger than others, the first question to be answered is: How fast can every pipe be refilled, i.e., which amount of water does increase its level by 1 cm?

This analogy helps to understand our task. The pipes are regions, the water levels are regional unemployment rates, and water is the subsidies given to regions which are transformed into jobs and change the unemployment rate.

An essential assumption here is the linear dependence of the regional unemployment on the number of subsidized jobs. In reality it is not that simple, but such an assumption literally meets the formulation of the problem: The grants are expected to have an effect, otherwise giving grants has no sense. The linearity is also not very restrictive. Indeed, the Taylor expansion of a process contains constant, linear, quadratic, and other constituents of higher degrees with vanishing role. Consequently, the first-order approximation can be always assumed linear.

2.2 Data

To be specific, consider West Germany with 204 labor market regions indexed by

$$r = 1, \ldots, 204 \ .$$

The same model will be applied to East Germany and to the whole of Germany.

Introduce vector notation for input data.

$\mathbf{u}$ the column 204-vector of regional numbers of **u**nemployed in 2002,

$\boldsymbol{u}$ the column 204-vector of regional $\boldsymbol{u}$nemployment rate in 2002, in %,

$\boldsymbol{a}$ the column 204-vector of $\boldsymbol{a}$id to regions from national German and European sources in the control period 2000–2002, in Mio EURO,

$\boldsymbol{j}$ the column 204-vector of $\boldsymbol{j}$obs subsidized in 2000–2002, in the number of jobs; if the rth region is not subsidized, the corresponding coordinate $j_r = 0$.

2.3 Unemployment as a function of subsidies

For each eligible region r express the regional unemployment rate y_r as a linear function of grant amount x_r, which we rewrite in an equivalent form better adaptable for interpretation:

$$\begin{aligned} y_r &= A_r + B_r \cdot x_r \\ &= \underbrace{n_r}_{\substack{\text{net}\\ \text{unem-}\\ \text{ploy-}\\ \text{ment}\\ \text{rate}}} - \underbrace{\frac{1}{p_r}}_{\substack{\text{'price' to}\\ \text{reduce}\\ \text{unem-}\\ \text{ployment}\\ \text{by 1\%}}} \cdot \underbrace{x_r}_{\substack{\text{grant}\\ \text{amount}}} . \end{aligned}$$

The regional net unemployment (with no aid) is certainly a function of numerous variables. However, in our model all these variables are 'passive', since we have no influence on them and they remain constant. Respectively, they are 'packed' together into the constant term $n_r = A_r$.

Now we make some intermediate estimations. From the given data, one can compute successively the following vectors.

$\boldsymbol{n}$ the column 204-vector of $\boldsymbol{n}$et unemployment rates in 2002 (with no aid). For this purpose we add the $\boldsymbol{j}$obs subsidized to the number of $\mathbf{u}$nemployed, and then proportionally derive the net unemployment rate:

$$\boldsymbol{n} = (\mathbf{u} + \boldsymbol{j}).*\boldsymbol{u}./\mathbf{u} \qquad (\text{recall } \mathbf{u} \neq \boldsymbol{u}) \ , \tag{2.1}$$

where $.*$ and $./$ are element-by-element multiplication and division of vectors.

Our estimate assumes that those who got jobs due to the governmental subsidies would otherwise remain unemployed. In reality unemployed can find jobs themselves, migrate, get retired, etc. If necessary, a comprehensive explanation of net unemployment can be substituted into the model.

$\boldsymbol{e}$ the column 204-vector of aid $\boldsymbol{e}$ffect (= the decrement in regional unemployment rates)

$$\boldsymbol{e} = \boldsymbol{n} - \boldsymbol{u} \ ,$$

$\boldsymbol{p}$ the column 204-vector of '$\boldsymbol{p}$rices' (= amount of aid required, in Mio EURO) for a 1%-decrement of regional unemployment rates

$$\boldsymbol{p} = \boldsymbol{a}./\boldsymbol{e} \qquad (\text{for non-eligible regions put } p_r = 0) \ .$$

From here we obtain the equation for the regional unemployment rate $\boldsymbol{y}$ as a function of the aid $\boldsymbol{x}$ to the regions:

$$\boldsymbol{y} = \boldsymbol{n} - \underbrace{\text{diagonalize}(\boldsymbol{p}.^{-1})}_{=\boldsymbol{Q}} \boldsymbol{x} \ , \tag{2.2}$$

where $\boldsymbol{Q}$ is the diagonal (204×204)-matrix with the diagonal elements obtained from the vector $\boldsymbol{p}$ by inverting its non-zero coordinates $p_r \neq 0 \ \rightarrow \ \frac{1}{p_r}$.

If statistical data were available for several control periods then equation (2.2) could be estimated econometrically more accurately.

2.4 Index of unemployment disparity

As already mentioned, the *index of regional unemployment disparity* is defined as the variance of regional unemployment rates. Its computing is convenient in a vector-matrix form.

Theorem 1 (Variance operator)
Consider a vector of m observations $\boldsymbol{y} = (y_1, \ldots, y_m)$. Then their variance

$$\mathsf{V}_y = \frac{1}{m-1} \sum_{r=1}^{m} \left(y_r - \frac{1}{m} \sum_{s=1}^{m} y_s \right)^2 = \frac{1}{m-1} \left\| \boldsymbol{V}\boldsymbol{y} \right\|^2 \ , \tag{2.3}$$

where the variance operator $\boldsymbol{V}$ *is the $(m \times m)$-matrix*

$$\boldsymbol{V} = \begin{pmatrix} 1-\frac{1}{m} & -\frac{1}{m} & \ldots & -\frac{1}{m} & -\frac{1}{m} \\ -\frac{1}{m} & 1-\frac{1}{m} & \ldots & -\frac{1}{m} & -\frac{1}{m} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ -\frac{1}{m} & -\frac{1}{m} & \ldots & -\frac{1}{m} & 1-\frac{1}{m} \end{pmatrix} = \begin{pmatrix} 1 & 0 & \ldots & 0 & 0 \\ 0 & 1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & \ldots & 0 & 1 \end{pmatrix} - \frac{1}{m} \ .$$

Obviously, to minimize the variance, it suffices to minimize $\left\| \boldsymbol{V}\boldsymbol{y} \right\|^2$.

2.5 Equalization of regional unemployment

Substituting (2.2) into (2.3), express the regional unemployment disparity as a function of regional subsidies:

$$\frac{1}{204-1} \left\| \boldsymbol{V}\boldsymbol{y} \right\|^2 = \frac{1}{203} \left\| \boldsymbol{V}\boldsymbol{n} - \boldsymbol{V}\boldsymbol{Q}\boldsymbol{x} \right\|^2 \ .$$

We have to take into account that the total budget is fixed, subsidies cannot be negative, and not all regions are eligible to receive them. Thus, the task of equalizing the regional unemployment is reduced to the linearly constrained quadratic optimization problem.

Theorem 2 (Equalization of regional unemployment)
The regional unemployment disparity is minimal if the 204-vector of regional subsidies $\boldsymbol{x} = \{x_r\}$ is a solution to the linearly constrained quadratic optimization problem

$$\begin{aligned} \text{minimize} \quad & \left\| \boldsymbol{V}\boldsymbol{Q}\boldsymbol{x} - \boldsymbol{V}\boldsymbol{n} \right\|^2 \\ \text{subject to} \quad & \sum_r x_r = A = \text{sum}(\boldsymbol{a}) \quad \textit{(the total aid granted)} \\ & x_r \geq 0 \quad \text{for all regions } r \\ & x_{r_n} = 0 \quad \text{for non-eligible regions } r_n \ , \end{aligned} \tag{2.4}$$

where the (204×204)*-matrices* $\boldsymbol{V}, \boldsymbol{Q}$ *and* 204*-vector* $\boldsymbol{n}$ *are defined in previous sections. The predicted equalized regional unemployment rates, average unemployment, and variance are respectively*

$$\begin{aligned} \boldsymbol{y} &= \boldsymbol{n} - \boldsymbol{Q}\boldsymbol{x} \\ \overline{y} &= \frac{\mathrm{sum}(\boldsymbol{y})}{204} \\ \mathsf{V}_y &= \frac{1}{203}\|\boldsymbol{V}\boldsymbol{y}\|^2 \ . \end{aligned} \tag{2.5}$$

The results computed with this model are discussed in the next chapter.

Chapter 3

Results

3.1 Overview

The model is implemented in the MATLAB programming language, Version 6, with the Optimization Toolbox, Version 2. The program performs three runs of the model from Theorem 2, separately for West and East Germany with their separate budgets, and then tentatively for the whole of Germany with a joint budget. Each run outputs a figure with an overview of the equalization stages; see Figures 3.1–3.3.

The detailed results of all the three runs are compiled in Table 3.1.

1. Figure 3.1 contains four graphs with their horizontal axes displaying West German region numbers 1–204 (their names are listed in Table 3.1), and vertical axes showing the unemployment rate. The regional unemployment rates are depicted by circles which stem from the average unemployment level, thereby visualizing the standard deviation. Exact numbers are given in Table 3.1.

   (a) The top graph shows the initial situation in 2000 with the average regional unemployment 7.24% and variance 5.15.

   (b) The next graph depicts the actual situation in 2002 (= vector $\boldsymbol{u}$) with the average regional unemployment 7.45% and variance 4.40. Compared with 2000, the situation got worse.

   (c) The third graph shows that the subsidies improved the situation. It displays the net regional unemployment estimated (= vector $\boldsymbol{n}$), as it could be without subsidies. The average regional unemployment is then 7.80% and the variance 6.78.

   (d) The bottom graph represents the indices equalized. Compared with the actual situation in graph (b), the average unemployment and especially the variance, which is the index optimized, are brought down to 7.28% and 3.50, respectively.

2. Figure 3.2 results from processing East German regions numbered 205–271, also listed by name in Table 3.1. In 2000–2002 the unemployment increased in spite of subsidies (17.68% in 2000 and 18.21% in 2002), which also could not equalize it (the variance 8.91 in 2000 and 9.76 in 2002). Moreover, the natural self-regulation could

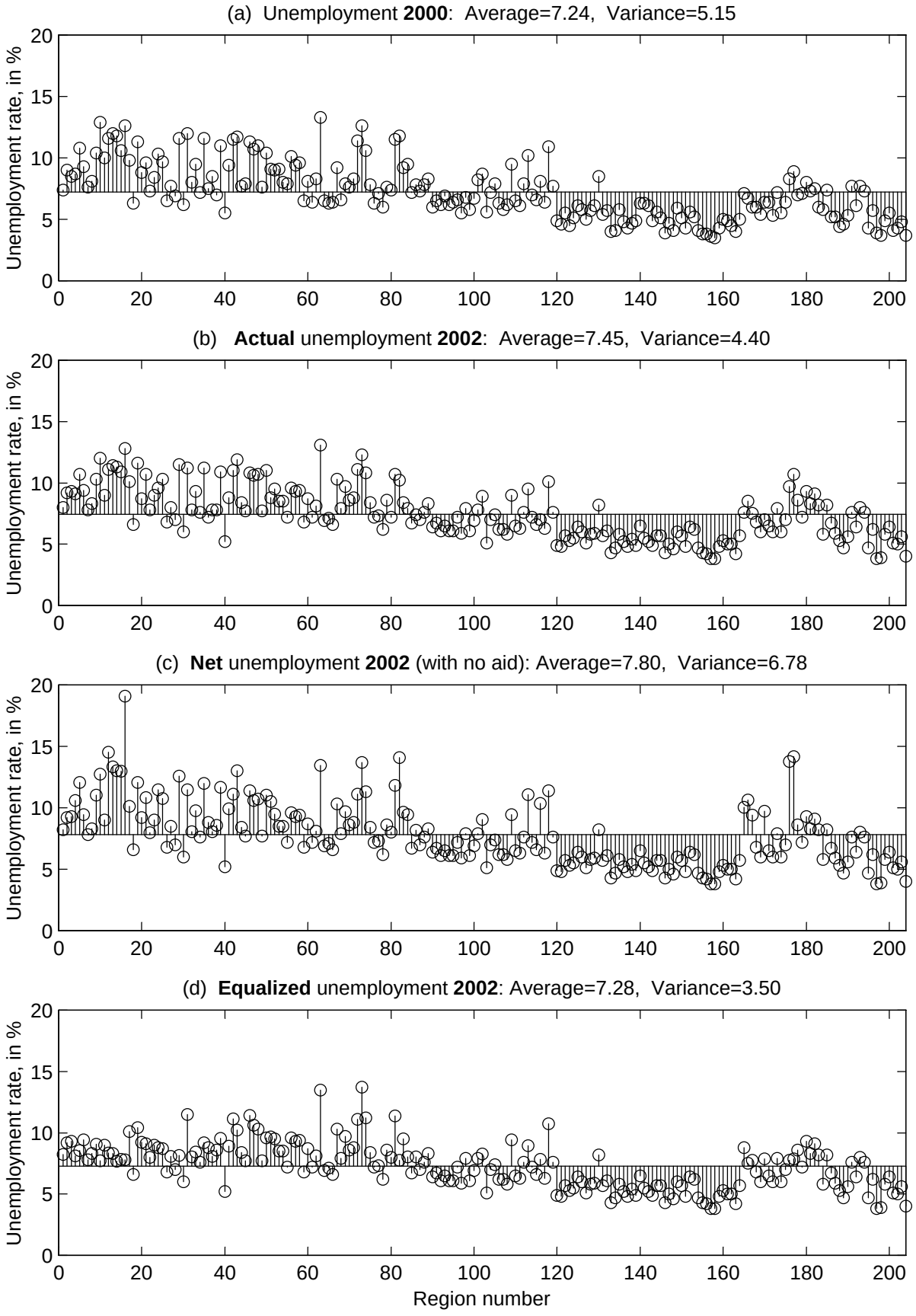


Figure 3.1: Equalization of unemployment in **West** Germany (regions 1–204)

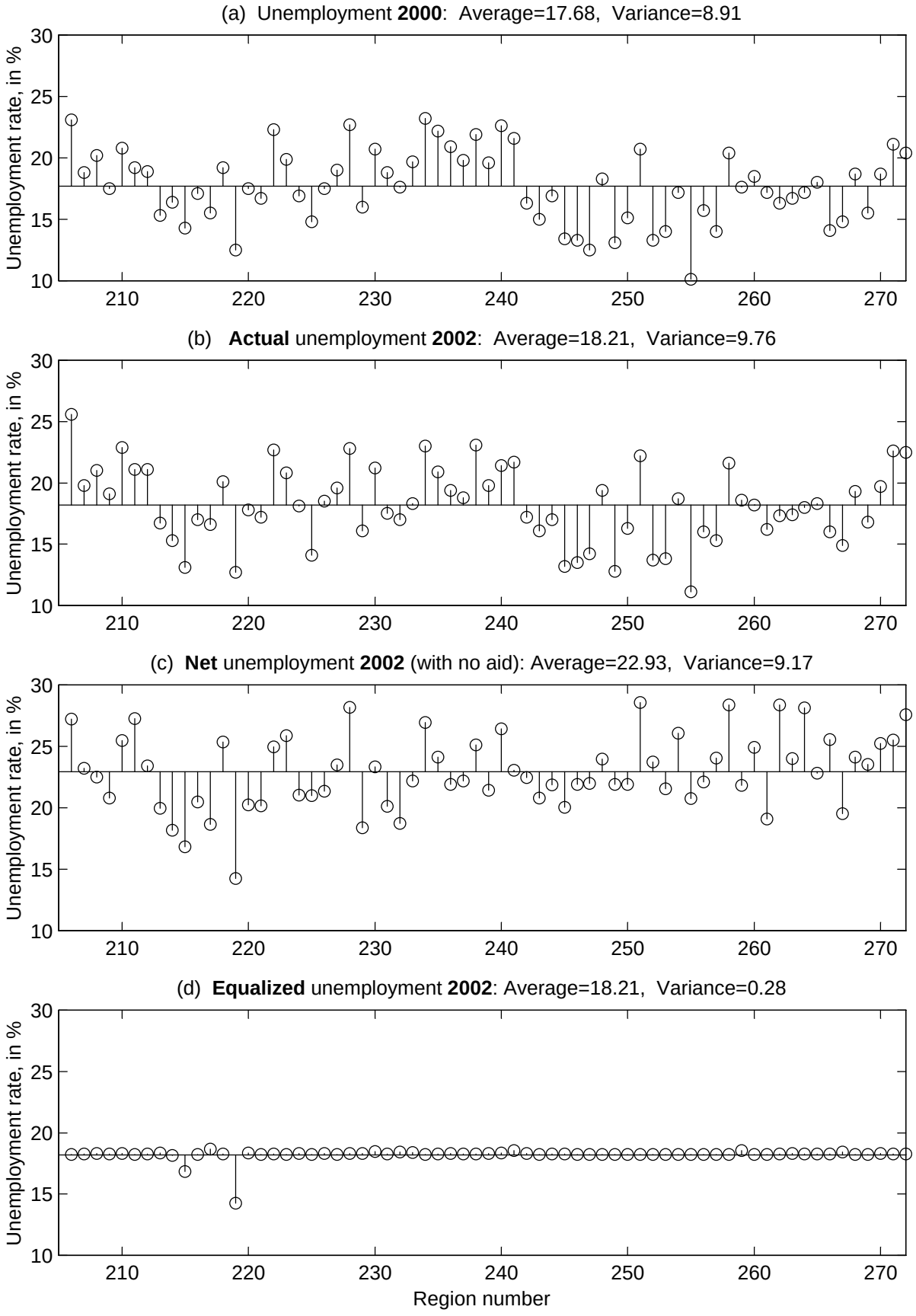


Figure 3.2: Equalization of unemployment in **East** Germany (regions 205–271)

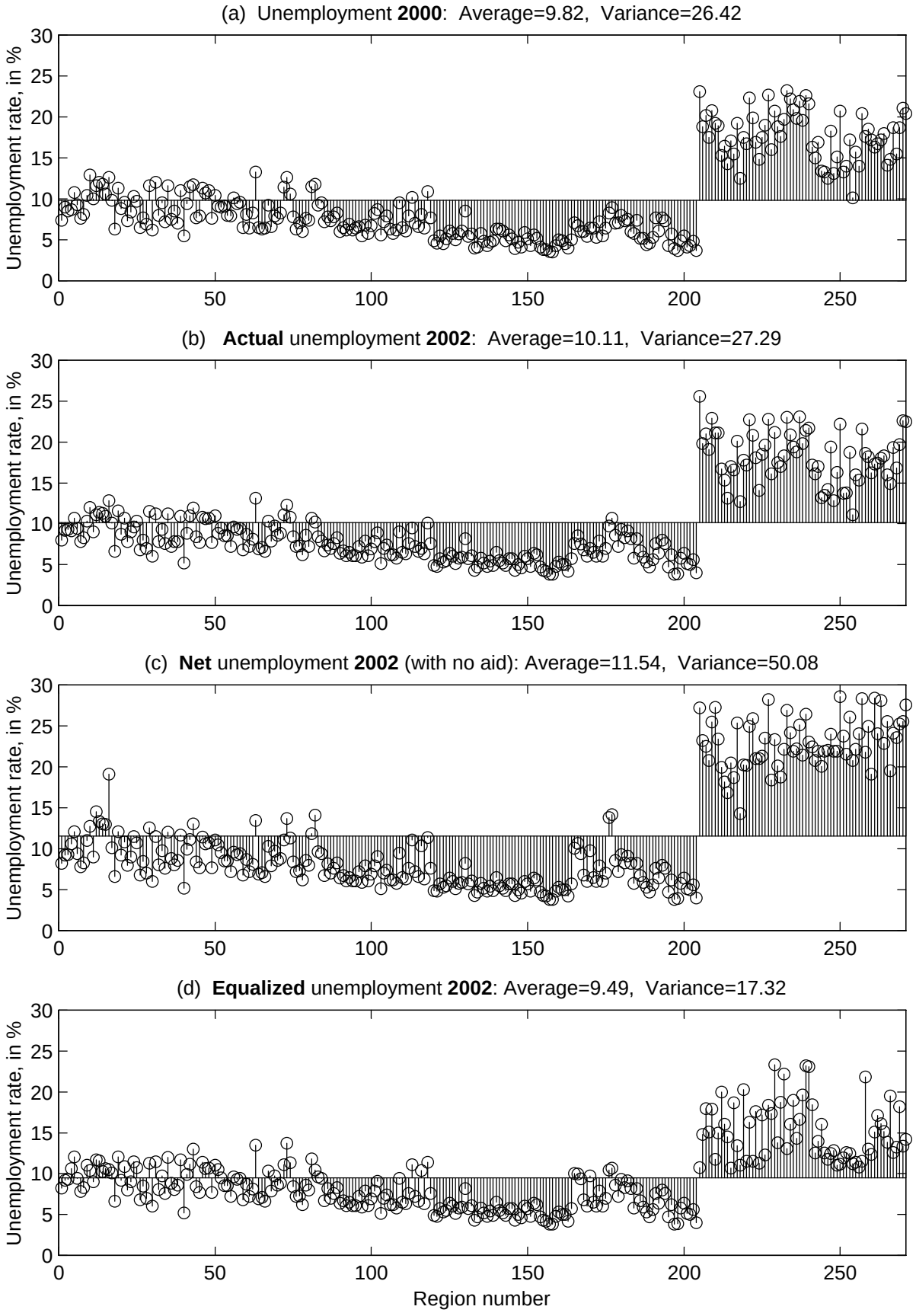


Figure 3.3: Equalization of unemployment in the **whole** of Germany (regions 1–271)

equalize it even better: The variance of the net unemployment 2002 in graph (c) is 9.17. So, the first aim of the subsidies was not attained.

The bottom graph in Figure 3.2 shows the regional unemployment rates of East Germany almost perfectly equalized with the variance reduced to 0.28. Since all East German regions are eligible to receive subsidies, the equalization for East Germany is more flexible than in case of West Germany. The subsidies are thereby channelled to reduce the variance rather than the average unemployment, which holds at the actual level 18.21.

3. Figure 3.3 illustrates what would be possible if the budgets of West and East Germany were not separate. The average unemployment could be reduced from the actual 10.11% to 9.49% and the variance from 27.29 to 17.42. This would require to redistribute 507.406 Mio EUR from West to East: Instead of 617 Mio EURO West Germany receives 110 Mio, or only 1.8% of the mutual budget.

3.2 Details

Table 3.1 with the program detailed output contains five vertical sections.

1. The first section displays the labor market regions and their numbers. As already mentioned, West German regions have numbers 1–204, and East German regions have numbers 205–271.

2. Section *Data* has six columns. The first two columns display the regional unemployment for the year 2000, in absolute figures and in %. These data are not used in computing but are important as the initial state of the control period.

   Next columns are vectors $\mathbf{u}, \boldsymbol{u}, \boldsymbol{a}, \boldsymbol{j}$ of $\boldsymbol{u}$nemployment in 2002, the granted $\boldsymbol{a}$id in 2000–2002, and the subsidized $\boldsymbol{j}$obs. Blank spaces mean that the region is not eligible to receive subsidies, and is not processed by the model.

3. The next section *Econometric estimation* contains three columns. Two columns contain coefficients of equation (2.2). They are vector $\boldsymbol{n}$, the $\boldsymbol{n}$et unemployment, which would occur with no aid, and vector $\boldsymbol{p}$, the '$\boldsymbol{p}$rice' which the grant-givers should pay to reduce the regional unemployment by 1%.

   The last column of the section, "Aid per one subsidized job", is auxiliary. It shows how 'expensive' is one job for the grant-givers.

4. Section *Separate optimization* contains two parts one upon another. The upper part in rows 1–204 displays the optimization output for West Germany, and the bottom section in rows 205–271 concerns East Germany, processed separately.

   Column "Redistribution of aid" displays the vector $\boldsymbol{x}-\boldsymbol{a}$, how the actual $\boldsymbol{a}$id should be changed with regard to the solution $\boldsymbol{x}$ of the problem (2.4). A negative number means that the region should give the subsidy or its fraction back; a positive number means an additional grant.

   Column "Equalized unemployment rate 2002" shows the vector $\boldsymbol{y}$ obtained from (2.6). This column is illustrated by the bottom graphs in Figures 3.1–3.3.

Table 3.1: Equalization of unemployment

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
1	Husum	7.4	5724	8.0	6409	1.460	183	8.23	6.391	7978	−1.460	8.23	0.23	183	−1.460	8.23	0.23	183
2	Heide	9.0	5628	9.2	6030			9.20				9.20				9.20		
3	Itzehoe	8.5	5530	9.3	6263			9.30				9.30				9.30		
4	Flensburg	8.7	11268	9.1	12318	7.050	2020	10.59	4.724	3490	4.689	8.11	−0.99	−1343	−7.050	10.59	1.49	2020
5	Lübeck	10.8	21477	10.7	21552	9.900	2727	12.05	7.312	3630	15.632	8.56	−2.14	−4306	−9.900	12.05	1.35	2727
6	Kiel	9.3	31794	9.4	33275	0.930	104	9.43	31.655	8942	−0.930	9.43	0.03	104	−0.930	9.43	0.03	104
7	Ratzeburg	7.6	6524	7.8	7089			7.80				7.80				7.80		
8	Hamburg	8.1	108313	8.3	115298			8.30				8.30				8.30		
9	Braunschweig	10.4	25198	10.3	25748	7.440	1844	11.04	10.086	4035	12.612	9.05	−1.25	−3126	−7.440	11.04	0.74	1844
10	Salzgitter	12.9	6794	12.0	6320	1.900	391	12.74	2.559	4859	10.935	7.73	−4.27	−2250	4.104	10.40	−1.60	−845
11	Wolfsburg	10.0	13791	9.0	13001			9.00				9.00				9.00		
12	Göttingen	11.6	14421	11.1	14239	21.080	4393	14.52	6.156	4799	16.872	8.36	−2.74	−3516	−3.492	11.67	0.57	728
13	Goslar	12.0	8859	11.4	8412	11.400	1435	13.34	5.862	7944	18.129	8.31	−3.09	−2282	−0.959	11.56	0.16	121
14	Helmstedt	11.8	5491	11.3	5398	3.730	821	13.02	2.170	4543	7.902	7.66	−3.64	−1739	2.260	10.26	−1.04	−497
15	Einbeck	10.6	7910	10.9	8317	6.770	1587	12.98	3.255	4266	9.930	7.85	−3.05	−2328	0.839	10.64	−0.26	−197
16	Osterode	12.6	5143	12.8	5288	18.020	2601	19.10	2.862	6928	14.367	7.78	−5.02	−2074	6.573	10.50	−2.30	−949
17	Hannover	9.8	53271	10.1	57904			10.10				10.10				10.10		
18	Sulingen	6.3	6471	6.6	6986			6.60				6.60				6.60		
19	Hameln	11.3	8838	11.6	9315	8.260	372	12.06	17.830	22204	21.215	10.41	−1.19	−955	−8.260	12.06	0.46	372
20	Hildesheim	8.8	12234	8.7	12539	7.700	740	9.21	14.997	10405	−7.700	9.21	0.51	740	−7.700	9.21	0.51	740
21	Holzminden	9.6	3631	10.7	4071	1.360	50	10.83	10.349	27200	16.602	9.10	−1.60	−610	−1.360	10.83	0.13	50
22	Nienburg	7.3	4304	7.8	4777	1.280	120	8.00	6.533	10667	−1.280	8.00	0.20	120	−1.280	8.00	0.20	120
23	Stadthagen	8.4	6502	9.0	7184			9.00				9.00				9.00		
24	Celle	10.3	8671	9.6	8389	15.940	1628	11.46	8.556	9791	7.009	8.78	−0.82	−716	−15.940	11.46	1.86	1628
25	Lüneburg	9.7	7886	10.3	8729	3.540	369	10.74	8.130	9593	12.960	8.71	−1.59	−1351	−3.540	10.74	0.44	369
26	Zeven	6.5	5170	6.8	5642			6.80				6.80				6.80		
27	Soltau	7.7	5145	8.0	5527	2.180	330	8.48	4.564	6606	−0.362	8.08	0.08	55	−2.180	8.48	0.48	330
28	Stade	6.9	6524	7.0	6734			7.00				7.00				7.00		
29	Uelzen	11.6	8125	11.5	8230	5.320	759	12.56	5.016	7009	16.760	8.16	−3.34	−2391	1.181	11.26	−0.24	−168
30	Verden	6.2	4099	6.0	4104			6.00				6.00				6.00		
31	Emden	12.0	12511	11.2	12465	9.620	312	11.48	34.316	30833	−9.620	11.48	0.28	312	−9.620	11.48	0.28	312
32	Westerstede	8.0	4525	7.8	4762	4.570	146	8.04	19.110	31301	−4.570	8.04	0.24	146	−4.570	8.04	0.24	146
33	Oldenburg	9.5	12753	9.3	13054	2.920	628	9.75	6.527	4650	5.716	8.42	−0.88	−1229	−2.920	9.75	0.45	628
34	Osnabrück	7.2	17761	7.6	19636			7.60				7.60				7.60		

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
35	Wilhelmshaven	11.6	12718	11.2	12611	8.760	901	12.00	10.947	9723	21.885	9.20	−2.00	−2251	−8.760	12.00	0.80	901
36	Cloppenburg	7.5	5202	7.2	5322	13.990	1192	8.81	8.675	11737	−13.895	8.80	1.60	1184	−13.990	8.81	1.61	1192
37	Lingen	8.5	11638	7.8	11385	6.900	368	8.05	27.368	18750	−6.900	8.05	0.25	368	−6.900	8.05	0.25	368
38	Nordhorn	7.0	4144	7.8	4890	7.290	491	8.58	9.308	14847	−7.290	8.58	0.78	491	−7.290	8.58	0.78	491
39	Leer	11.0	7775	10.9	8160	9.990	581	11.68	12.872	17194	17.518	9.54	−1.36	−1019	−9.990	11.68	0.78	581
40	Vechta	5.5	3506	5.2	3572			5.20				5.20				5.20		
41	Nordenham	9.4	4124	8.8	3973	10.370	504	9.92	9.289	20575	−1.018	8.91	0.11	49	−10.370	9.92	1.12	504
42	Bremen	11.5	40395	11.0	39753	6.090	464	11.13	47.433	13125	−6.090	11.13	0.13	464	−6.090	11.13	0.13	464
43	Bremerhaven	11.7	17720	11.9	18359	18.860	1746	13.03	16.665	10802	28.240	10.21	−1.69	−2614	−18.860	13.03	1.13	1746
44	Hëxter	7.7	5412	8.4	6109			8.40				8.40				8.40		
45	Düsseldorf	7.9	60257	7.7	60234			7.70				7.70				7.70		
46	Duisburg	11.3	62320	10.8	61568	48.660	3466	11.41	80.034	14039	−48.660	11.41	0.61	3466	−48.660	11.41	0.61	3466
47	Essen	10.7	38323	10.6	38770			10.60				10.60				10.60		
48	Krefeld	11.0	12409	10.7	12200	0.090	6	10.71	17.103	15000	7.143	10.28	−0.42	−476	−0.090	10.71	0.01	6
49	Viersen	7.6	10900	7.7	11362			7.70				7.70				7.70		
50	Mönchengladbach	10.4	13325	11.0	14411	0.590	59	11.05	13.101	10000	18.613	9.58	−1.42	−1861	−0.590	11.05	0.05	59
51	Heinsberg	9.1	9817	8.8	10070	23.110	1946	10.50	13.590	11876	−11.756	9.67	0.87	990	−23.110	10.50	1.70	1946
52	Wuppertal	9.0	23393	9.5	25093			9.50				9.50				9.50		
53	Schwelm	9.1	15245	8.5	14465			8.50				8.50				8.50		
54	Remscheid	8.0	4880	8.5	5237			8.50				8.50				8.50		
55	Kleve	7.9	11088	7.2	10763			7.20				7.20				7.20		
56	Aachen	10.1	25710	9.6	25476			9.60				9.60				9.60		
57	Köln	9.4	77411	9.3	80586			9.30				9.30				9.30		
58	Leverkusen	9.6	7478	9.4	7449			9.40				9.40				9.40		
59	Bonn	6.5	26724	6.8	29611			6.80				6.80				6.80		
60	Düren	8.1	9668	8.7	10929			8.70				8.70				8.70		
61	Euskirchen	6.4	5434	7.2	6501			7.20				7.20				7.20		
62	Gummersbach	8.3	11251	8.1	11498			8.10				8.10				8.10		
63	Gelsenkirchen	13.3	73103	13.1	73939	21.870	2077	13.47	59.431	10530	−21.870	13.47	0.37	2077	−21.870	13.47	0.37	2077
64	Münster	6.5	23394	6.9	26603			6.90				6.90				6.90		
65	Borken	6.3	10497	7.1	12621			7.10				7.10				7.10		
66	Steinfurt	6.4	12881	6.6	14013			6.60				6.60				6.60		
67	Bielefeld	9.2	26261	10.3	30106			10.30				10.30				10.30		
68	Gütersloh	6.6	11309	7.9	14237			7.90				7.90				7.90		

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
69	Detmold	7.9	13579	9.7	17173			9.70				9.70				9.70		
70	Minden	7.6	11670	8.6	13433			8.60				8.60				8.60		
71	Paderborn	8.3	11335	8.8	12720			8.80				8.80				8.80		
72	Bochum	11.4	20328	11.1	20229			11.10				11.10				11.10		
73	Dortmund	12.6	68307	12.3	69006	87.710	7866	13.70	62.557	11151	−87.710	13.70	1.40	7866	−87.710	13.70	1.40	7866
74	Hagen	10.6	10537	10.8	10751	11.800	525	11.33	22.374	22476	−9.140	11.21	0.41	407	−11.800	11.33	0.53	525
75	Lüdenscheid	7.8	17335	8.4	19061			8.40				8.40				8.40		
76	Meschede	6.3	8647	7.2	10166			7.20				7.20				7.20		
77	Siegen	7.1	9890	7.3	10444			7.30				7.30				7.30		
78	Olpe	6.0	4137	6.2	4478			6.20				6.20				6.20		
79	Soest	7.6	10965	8.6	12998			8.60				8.60				8.60		
80	Korbach	7.4	5854	7.2	6020	4.810	672	8.00	5.985	7158	−4.810	8.00	0.80	672	−4.810	8.00	0.80	672
81	Kassel	11.5	24146	10.7	23151	26.280	2442	11.83	23.284	10762	−15.564	11.37	0.67	1446	−26.280	11.83	1.13	2442
82	Eschwege	11.8	6445	10.2	5725	10.530	2179	14.08	2.712	4832	6.634	7.75	−2.45	−1373	−0.679	10.45	0.25	141
83	Schwalm-Eder	9.2	8224	8.4	7913	15.590	1160	9.63	12.660	13440	−13.950	9.50	1.10	1038	−15.590	9.63	1.23	1160
84	Hersfeld	9.5	5715	7.9	4874	6.410	942	9.43	4.198	6805	−0.483	8.02	0.12	71	−6.410	9.43	1.53	942
85	Marburg	7.2	8448	6.7	8134			6.70				6.70				6.70		
86	Lauterbach	7.8	4374	7.4	4345	3.240	449	8.16	4.237	7216	−2.635	8.02	0.62	365	−3.240	8.16	0.76	449
87	Fulda	7.3	7482	7.0	7531			7.00				7.00				7.00		
88	Wetzlar	7.8	9902	7.6	10001			7.60				7.60				7.60		
89	Gießen	8.3	10247	8.3	10682			8.30				8.30				8.30		
90	Limburg	6.0	4907	6.4	5438			6.40				6.40				6.40		
91	Wiesbaden	6.5	14788	6.7	15716			6.70				6.70				6.70		
92	Frankfurt/Main	6.2	64646	6.1	66424			6.10				6.10				6.10		
93	Hanau	6.9	14029	6.5	13708			6.50				6.50				6.50		
94	Darmstadt	6.2	13145	6.1	13458			6.10				6.10				6.10		
95	Erbach	6.4	3068	6.1	3019			6.10				6.10				6.10		
96	Altenkirchen	6.6	4110	7.2	4778			7.20				7.20				7.20		
97	Montabaur	5.5	5328	5.9	6049			5.90				5.90				5.90		
98	Neuwied	6.8	5779	7.9	7004			7.90				7.90				7.90		
99	Ahrweiler	5.8	3498	6.1	3839			6.10				6.10				6.10		
100	Koblenz	6.7	14367	6.9	15425			6.90				6.90				6.90		
101	Bad Kreuznach	8.2	6086	7.8	6192	1.030	81	7.90	10.095	12716	−1.030	7.90	0.10	81	−1.030	7.90	0.10	81
102	Idar-Oberstein	8.7	3638	8.9	3906	0.910	71	9.06	5.625	12817	3.567	8.27	−0.63	−278	−0.910	9.06	0.16	71

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
103	Cochem	5.6	1716	5.1	1664			5.10				5.10				5.10		
104	Simmern	7.2	3603	7.0	3721			7.00				7.00				7.00		
105	Trier	7.9	8203	7.4	8075			7.40				7.40				7.40		
106	Bernkastel-Wittlich	6.3	3396	6.2	3560			6.20				6.20				6.20		
107	Daun	5.8	1678	6.2	1901			6.20				6.20				6.20		
108	Bitburg	6.2	2485	5.8	2474			5.80				5.80				5.80		
109	Kaiserslautern	9.5	16411	9.0	16077	8.500	786	9.44	19.318	10814	−8.500	9.44	0.44	786	−8.500	9.44	0.44	786
110	Landau	6.5	4722	6.5	4906			6.50				6.50				6.50		
111	Mainz	6.1	11613	6.3	12520			6.30				6.30				6.30		
112	Alzey-Worms	7.9	7775	7.6	7840			7.60				7.60				7.60		
113	Pirmasens	10.2	9105	9.5	8652	15.090	1435	11.08	9.577	10516	5.170	8.96	−0.54	−492	−15.090	11.08	1.58	1435
114	Ludwigshafen	7.0	20256	7.2	21359			7.20				7.20				7.20		
115	Germersheim	6.6	4031	6.6	4235			6.60				6.60				6.60		
116	Merzig	8.1	3793	7.0	3396	10.940	1631	10.36	3.254	6708	−2.764	7.85	0.85	412	−10.940	10.36	3.36	1631
117	St. Wendel	6.4	2796	6.3	2871			6.30				6.30				6.30		
118	Saarbrücken	10.9	35391	10.1	33523	25.500	4283	11.39	19.761	5954	−12.833	10.75	0.65	2155	−25.500	11.39	1.29	4283
119	Homburg/Saar	7.7	5598	7.6	5683			7.60				7.60				7.60		
120	Stuttgart	4.9	58819	4.9	60637			4.90				4.90				4.90		
121	Göppingen	4.6	5977	4.8	6296			4.80				4.80				4.80		
122	Heilbronn	5.5	12261	5.7	13091			5.70				5.70				5.70		
123	Schwäbisch Hall	4.5	6649	5.3	8034			5.30				5.30				5.30		
124	Tauberbischofsheim	5.1	3420	5.5	3817			5.50				5.50				5.50		
125	Heidenheim	6.1	4038	6.4	4338			6.40				6.40				6.40		
126	Aalen	5.8	8982	6.0	9576			6.00				6.00				6.00		
127	Baden-Baden	5.0	6970	5.1	7356			5.10				5.10				5.10		
128	Karlsruhe	5.7	19692	5.8	20960			5.80				5.80				5.80		
129	Heidelberg	6.1	19466	5.9	19619			5.90				5.90				5.90		
130	Mannheim	8.5	23577	8.2	23447			8.20				8.20				8.20		
131	Mosbach	5.4	3819	5.7	4193			5.70				5.70				5.70		
132	Pforzheim	5.7	8996	6.1	9817			6.10				6.10				6.10		
133	Calw	4.0	3053	4.3	3478			4.30				4.30				4.30		
134	Freudenstadt	4.1	2470	4.7	2963			4.70				4.70				4.70		
135	Freiburg	5.8	16450	5.8	17540			5.80				5.80				5.80		
136	Offenburg	4.8	9885	5.2	11139			5.20				5.20				5.20		

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
137	Rottweil	4.3	3043	4.8	3485			4.80				4.80				4.80		
138	Villingen-Schwenningen	4.7	4909	5.4	5866			5.40				5.40				5.40		
139	Tuttlingen	4.9	3350	4.9	3435			4.90				4.90				4.90		
140	Konstanz	6.3	8197	6.5	8824			6.50				6.50				6.50		
141	Lörrach	6.3	6790	5.5	6136			5.50				5.50				5.50		
142	Waldshut	6.1	4977	5.2	4487			5.20				5.20				5.20		
143	Reutlingen/Tübingen	4.9	11809	4.9	12314			4.90				4.90				4.90		
144	Balingen	5.6	5582	5.7	5790			5.70				5.70				5.70		
145	Ulm	5.1	11841	5.7	13664			5.70				5.70				5.70		
146	Biberach	3.9	3451	4.3	4033			4.30				4.30				4.30		
147	Friedrichshafen	4.7	4561	5.0	5043			5.00				5.00				5.00		
148	Ravensburg	4.1	5311	4.6	6196			4.60				4.60				4.60		
149	Sigmaringen	5.9	3807	6.0	4047			6.00				6.00				6.00		
150	Bad Reichenhall	5.1	2440	5.7	2738			5.70				5.70				5.70		
151	Traunstein	4.3	3494	4.8	4071			4.80				4.80				4.80		
152	Burghausen	5.6	2923	6.4	3461			6.40				6.40				6.40		
153	Mühldorf	5.2	2730	6.2	3377			6.20				6.20				6.20		
154	Rosenheim	4.1	5816	4.7	6996			4.70				4.70				4.70		
155	Bad Tölz	3.8	3926	4.3	4606			4.30				4.30				4.30		
156	Garmisch-Partenkirchen	3.8	1619	4.2	1832			4.20				4.20				4.20		
157	Weilheim	3.6	2206	3.8	2461			3.80				3.80				3.80		
158	Landsberg	3.5	1741	3.8	2004			3.80				3.80				3.80		
159	München	4.3	53287	4.8	63104			4.80				4.80				4.80		
160	Ingolstadt	5.0	10773	5.3	11892			5.30				5.30				5.30		
161	Kelheim-Mainburg	4.9	2673	5.0	2895			5.00				5.00				5.00		
162	Landshut	4.5	4547	5.0	5357			5.00				5.00				5.00		
163	Dingolfing	4.0	1867	4.2	2026			4.20				4.20				4.20		
164	Eggenfelden/Pfarrkirchen	5.0	2899	5.7	3384			5.70				5.70				5.70		
165	Passau	7.1	8130	7.6	8926	20.820	2870	10.04	8.520	7254	−10.006	8.77	1.17	1379	−20.820	10.04	2.44	2870
166	Freyung	6.7	2684	8.5	3441	2.650	862	10.63	1.245	3074	1.249	7.50	−1.00	−406	−1.782	9.93	1.43	580
167	Regen-Zwisel	6.0	2418	7.5	3113	4.940	783	9.39	2.619	6309	−0.622	7.74	0.24	99	−4.940	9.39	1.89	783
168	Deggendorf	6.0	3438	6.8	4060			6.80				6.80				6.80		
169	Straubing	5.4	3750	6.0	4337			6.00				6.00				6.00		
170	Cham	6.4	4088	7.0	4642	9.090	1812	9.73	3.327	5017	−2.868	7.86	0.86	572	−9.090	9.73	2.73	1812

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
171	Regensburg	6.4	9862	6.5	10374			6.50				6.50				6.50		
172	Schwandorf	5.3	3816	6.0	4382			6.00				6.00				6.00		
173	Amberg	7.2	5264	7.9	6014			7.90				7.90				7.90		
174	Neumarkt	5.5	3417	6.0	3862			6.00				6.00				6.00		
175	Weiden	6.4	4538	7.0	5189			7.00				7.00				7.00		
176	Marktredwitz	8.3	6826	9.7	8044	11.150	3389	13.79	2.728	3290	5.302	7.76	−1.94	−1611	−2.063	10.46	0.76	627
177	Hof	8.9	7081	10.7	8547	11.910	2776	14.18	3.427	4290	9.666	7.88	−2.82	−2253	−0.010	10.70	0.00	2
178	Bayreuth	7.0	6485	8.6	8100			8.60				8.60				8.60		
179	Bamberg	7.1	7494	7.2	8035			7.20				7.20				7.20		
180	Kulmbach	8.0	3203	9.3	3771			9.30				9.30				9.30		
181	Kronach	7.3	2921	8.3	3352			8.30				8.30				8.30		
182	Coburg	7.5	5197	9.1	6319			9.10				9.10				9.10		
183	Lichtenfels	6.0	2173	8.2	3005			8.20				8.20				8.20		
184	Erlangen	5.8	10160	5.8	10516			5.80				5.80				5.80		
185	Nürnberg	7.4	39817	8.2	44664			8.20				8.20				8.20		
186	Weißenburg-Gunzenhausen	5.2	2479	6.7	3255			6.70				6.70				6.70		
187	Ansbach	5.2	5727	5.9	6657			5.90				5.90				5.90		
188	Neustadt/Aisch	4.4	2210	5.3	2757			5.30				5.30				5.30		
189	Kitzingen	4.6	2091	4.7	2235			4.70				4.70				4.70		
190	Würzburg	5.3	7521	5.6	8283			5.60				5.60				5.60		
191	Schweinfurt	7.7	6423	7.6	6584			7.60				7.60				7.60		
192	Haßfurt	6.1	2695	6.4	2966			6.40				6.40				6.40		
193	Bad Neustadt/Saale	7.7	3228	8.0	3476			8.00				8.00				8.00		
194	Bad Kissingen	7.3	3918	7.6	4199			7.60				7.60				7.60		
195	Lohr am Main	4.3	2951	4.7	3275			4.70				4.70				4.70		
196	Aschaffenburg	5.7	11024	6.2	12448			6.20				6.20				6.20		
197	Donauwörth-Nördlingen	3.9	2517	3.8	2562			3.80				3.80				3.80		
198	Dillingen	3.7	1748	3.9	1929			3.90				3.90				3.90		
199	Günzburg	4.9	2983	5.8	3658			5.80				5.80				5.80		
200	Augsburg	5.5	16765	6.4	20294			6.40				6.40				6.40		
201	Memmingen	4.1	3703	5.1	4687			5.10				5.10				5.10		
202	Kaufbeuren	4.3	3703	5.0	4441			5.00				5.00				5.00		
203	Kempten	4.8	5141	5.6	6105			5.60				5.60				5.60		
204	Lindau	3.7	1411	4.0	1553			4.00				4.00				4.00		

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	$\boldsymbol{u}$ Unemployment rate 2002	u Unemployed 2002	$\boldsymbol{a}$ Granted aid	$\boldsymbol{j}$ Subsidized jobs	$\boldsymbol{n}$ Net unemployment rate 2002 with no aid	$\boldsymbol{p}$ Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$\boldsymbol{x-a}$ Redistribution of aid	$\boldsymbol{y}$ Equalized unemployment rate 2002	$\boldsymbol{y-u}$ Increment in unemployment rate 2002	Increment in unemployed 2002	$\boldsymbol{x-a}$ Redistribution of aid	$\boldsymbol{y}$ Equalized unemployment rate 2002	$\boldsymbol{y-u}$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
205	Pasewalk	23.1	9733	25.6	10581	5.720	670	27.22	3.529	8537	26.040	18.22	−7.38	−3050	52.440	10.74	−14.86	−6142
206	Greifswald	18.8	16306	19.8	17010	51.090	2938	23.22	14.939	17389	22.907	18.27	−1.53	−1317	75.121	14.77	−5.03	−4320
207	Stralsund	20.2	18242	21.0	18776	35.560	1327	22.48	23.959	26797	64.615	18.30	−2.70	−2411	72.849	17.96	−3.04	−2719
208	Bergen	17.5	6883	19.1	7512	26.660	663	20.79	15.815	40211	13.124	18.27	−0.83	−326	63.559	15.08	−4.02	−1581
209	Neubrandenburg	20.8	27876	22.9	30451	61.020	3405	25.46	23.830	17921	109.555	18.30	−4.60	−6113	118.823	17.91	−4.99	−6630
210	Waren	19.2	7017	21.1	7822	39.600	2289	27.27	6.413	17300	18.393	18.23	−2.87	−1063	59.911	11.76	−9.34	−3463
211	Güstrow	18.9	10727	21.1	12015	35.670	1307	23.40	15.541	27292	43.995	18.27	−2.83	−1612	95.044	14.98	−6.12	−3483
212	Rostock	15.3	25500	16.7	27549	106.450	5362	19.95	32.750	19853	−53.669	18.34	1.64	2703	−106.450	19.95	3.25	5362
213	Wismar	16.4	13848	15.3	13111	53.110	2460	18.17	18.501	21589	−53.110	18.17	2.87	2460	−13.510	16.03	0.73	626
214	Schwerin	14.3	17580	13.1	15999	53.170	4573	16.84	14.200	11627	−53.170	16.84	3.74	4573	−20.026	14.51	1.41	1722
215	Parchim	17.1	9300	17.0	9450	11.720	1923	20.46	3.388	6095	−4.133	18.22	1.22	678	21.381	10.69	−6.31	−3508
216	Berlin	15.5	328077	16.6	366447	536.660	45658	18.67	259.469	11754	−536.660	18.67	2.07	45658	−536.660	18.67	2.07	45658
217	Brandenburg a.d. Havel	19.2	13688	20.1	14444	58.590	3789	25.37	11.112	15463	20.545	18.25	−1.85	−1329	74.239	13.42	−6.68	−4801
218	Belzig	12.5	5027	12.7	5868	6.830	722	14.26	4.371	9460	−6.830	14.26	1.56	722	7.271	11.04	−1.66	−769
219	Cottbus	17.5	30024	17.8	30624	78.380	4224	20.26	31.924	18556	−17.093	18.34	0.54	921	−78.380	20.26	2.46	4224
220	Eberswalde	16.7	6970	17.2	6385	16.730	1095	20.15	5.672	15279	−5.837	18.23	1.03	382	32.350	11.50	−5.70	−2117
221	Prenzlau	22.3	17491	22.7	17449	43.490	1744	24.97	19.168	24937	84.653	18.28	−4.42	−3395	123.324	16.27	−6.43	−4945
222	Finsterwalde	19.9	13448	20.8	13878	28.930	3387	25.88	5.699	8541	14.651	18.23	−2.57	−1715	52.967	11.51	−9.29	−6201
223	Frankfurt/Oder	16.9	29316	18.1	22322	67.330	3615	21.03	22.970	18625	−4.574	18.30	0.20	246	11.262	17.61	−0.49	−605
224	Luckenwalde	14.8	6065	14.1	5010	35.250	2454	21.01	5.104	14364	−21.063	18.23	4.13	1466	14.313	11.30	−2.80	−996
225	Neuruppin	17.5	14230	18.5	18839	61.830	2888	21.34	21.802	21409	4.482	18.29	−0.21	−209	28.410	17.20	−1.30	−1327
226	Perleberg	19.0	9314	19.6	9450	31.250	1886	23.51	7.989	16569	10.877	18.24	−1.36	−656	58.197	12.32	−7.28	−3512
227	Senftenberg	22.7	16967	22.8	16651	135.020	3936	28.19	25.052	34304	112.546	18.31	−4.49	−3281	111.589	18.35	−4.45	−3253
228	Salzwedel	16.0	8241	16.1	8266	50.530	1166	18.37	22.250	43336	−48.865	18.30	2.20	1128	−27.927	17.36	1.26	644
229	Stendal	20.7	14944	21.2	14805	140.010	1493	23.34	65.490	93778	178.697	18.47	−2.73	−1906	−140.010	23.34	2.14	1493
230	Burg	18.8	9783	17.5	8948	31.910	1337	20.11	12.203	23867	−9.220	18.26	0.76	386	45.095	13.80	−3.70	−1889
231	Magdeburg	17.6	40586	17.0	38540	100.850	3923	18.73	58.280	25707	−84.050	18.44	1.44	3269	−100.850	18.73	1.73	3923
232	Halberstadt	19.7	25986	18.3	23845	192.440	5039	22.17	49.762	38190	−5.358	18.41	0.11	140	−192.440	22.17	3.87	5039
233	Staßfurt	23.2	12150	23.0	11809	39.660	2020	26.93	10.081	19634	47.914	18.25	−4.75	−2440	100.257	13.05	−9.95	−5106
234	Schönebeck	22.2	16503	20.9	15126	59.930	2347	24.14	18.480	25535	48.401	18.28	−2.62	−1895	90.127	16.02	−4.88	−3530
235	Dessau	20.9	24916	19.4	22623	67.480	2941	21.92	26.756	22945	29.044	18.31	−1.09	−1266	12.093	18.95	−0.45	−527
236	Wittenberg	19.8	13604	18.8	12531	45.980	2253	22.18	13.603	20408	7.329	18.26	−0.54	−359	61.222	14.30	−4.50	−3000
237	Sangerhausen	21.9	19389	23.1	19903	40.350	1724	25.10	20.166	23405	97.041	18.29	−4.81	−4146	130.699	16.62	−6.48	−5584
238	Halle	19.6	34424	19.8	33984	46.550	2787	21.42	28.668	16703	42.364	18.32	−1.48	−2536	5.060	19.62	−0.18	−303
239	Bitterfeld	22.6	12582	21.4	11416	193.890	2672	26.41	38.710	72564	117.565	18.36	−3.04	−1620	−68.614	23.17	1.77	946

Table 3.1: Equalization of unemployment (continued)

Nr.	Labour market region	Data						Econometric estimation			Separate equalization				Joint equalization			
		Unemployment rate 2000	Unemployed 2000	u Unemployment rate 2002	u Unemployed 2002	a Granted aid	j Subsidized jobs	n Net unemployment rate 2002 with no aid	p Aid needed to reduce unemployment by 1%	Aid per one subsidized job	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002	$x-a$ Redistribution of aid	y Equalized unemployment rate 2002	$y-u$ Increment in unemployment rate 2002	Increment in unemployed 2002
		%	Number	%	Number	Mio EUR	Number	%	Mio EUR	EUR	Mio EUR	%	%	Number	Mio EUR	%	%	Number
240	Naumburg	21.6	39399	21.7	38615	120.020	2417	23.06	88.364	49657	277.107	18.56	−3.14	−5580	−120.020	23.06	1.36	2417
241	Erfurt	16.3	24457	17.2	26120	133.440	7988	22.46	25.368	16705	−28.130	18.31	1.11	1684	−31.900	18.46	1.26	1910
242	Weimar	15.0	11650	16.1	12831	40.510	3734	20.79	8.646	10849	−18.513	18.24	2.14	1706	30.716	12.55	−3.55	−2831
243	Gera	16.9	20773	17.0	20690	61.980	5935	21.88	12.710	10443	−15.984	18.26	1.26	1531	38.337	13.98	−3.02	−3671
244	Jena	13.4	13386	13.2	13465	126.600	6997	20.06	18.457	18093	−93.776	18.28	5.08	5183	−51.951	16.01	2.81	2871
245	Suhl	13.3	8842	13.5	8935	71.520	5567	21.91	8.503	12847	−40.308	18.24	4.74	3138	8.530	12.50	−1.00	−664
246	Eichsfeld	12.5	7290	14.2	8350	50.490	4588	22.00	6.471	11005	−26.094	18.23	4.03	2371	15.668	11.78	−2.42	−1424
247	Nordhausen	18.3	9196	19.4	9659	38.030	2272	23.96	8.334	16739	9.668	18.24	−1.16	−578	58.028	12.44	−6.96	−3467
248	Eisenach	13.1	12947	12.8	12596	85.580	8957	21.90	9.402	9555	−51.188	18.24	5.44	5357	−0.138	12.81	0.01	14
249	Mühlhausen	15.1	9138	16.3	9839	24.840	3386	21.91	4.428	7336	−8.520	18.22	1.92	1161	23.218	11.06	−5.24	−3165
250	Sondershausen	20.7	9908	22.2	10489	29.590	3017	28.59	4.634	9808	18.420	18.22	−3.98	−1878	51.300	11.13	−11.07	−5231
251	Meiningen	13.3	10081	13.7	10453	69.100	7660	23.74	6.883	9021	−31.207	18.23	4.53	3459	12.222	11.92	−1.78	−1355
252	Gotha	14.0	10850	13.8	10798	67.910	6048	21.53	8.786	11229	−39.024	18.24	4.44	3475	10.570	12.60	−1.20	−941
253	Arnstadt	17.2	10743	18.7	11801	61.560	4645	26.06	8.364	13253	3.847	18.24	−0.46	−290	52.292	12.45	−6.25	−3946
254	Sonneberg	10.1	3647	11.1	4012	47.810	3494	20.77	4.946	13683	−35.244	18.23	7.13	2576	−0.691	11.24	0.14	50
255	Saalfeld	15.7	10586	16.0	10792	32.560	4126	22.12	5.323	7891	−11.857	18.23	2.23	1503	24.629	11.37	−4.63	−3121
256	Pö	14.0	7248	15.3	8005	31.650	4573	24.04	3.621	6921	−10.576	18.22	2.92	1528	16.398	10.77	−4.53	−2369
257	Altenburg	20.4	11926	21.6	12443	38.110	3894	28.36	5.638	9787	19.006	18.23	−3.37	−1942	57.031	11.48	−10.12	−5827
258	Leipzig	17.6	69140	18.6	73167	262.640	12629	21.81	81.808	20797	5.116	18.54	−0.06	−246	−262.640	21.81	3.21	12629
259	Torgau/Oschatz	18.5	17278	18.2	17025	66.870	6298	24.93	9.932	10618	−0.460	18.25	0.05	43	51.627	13.00	−5.20	−4862
260	Grimma	17.2	11890	16.2	11490	23.570	2052	19.09	8.147	11486	−16.612	18.24	2.04	1446	31.194	12.37	−3.83	−2716
261	Freiberg	16.3	20643	17.3	22033	175.140	14095	28.37	15.825	12426	−15.354	18.27	0.97	1236	35.058	15.08	−2.22	−2821
262	Chemnitz	16.7	46713	17.4	47897	142.860	18243	24.03	21.556	7831	−19.259	18.29	0.89	2459	6.247	17.11	−0.29	−798
263	Annaberg	17.2	28002	18.0	29600	189.870	16647	28.12	18.756	11406	−5.291	18.28	0.28	464	35.252	16.12	−1.88	−3091
264	Zwickau	18.0	22081	18.3	22399	72.440	5551	22.84	15.973	13050	0.466	18.27	−0.03	−36	50.524	15.14	−3.16	−3872
265	Plauen	14.1	19895	16.0	22494	116.770	13412	25.54	12.240	8706	−27.610	18.26	2.26	3171	26.712	13.82	−2.18	−3068
266	Dresden	14.8	48798	14.9	49409	238.700	15272	19.51	51.829	15630	−182.234	18.42	3.52	11659	−238.700	19.51	4.61	15272
267	Riesa	18.7	11901	19.3	12177	42.110	3040	24.12	8.740	13852	9.251	18.24	−1.06	−668	58.726	12.58	−6.72	−4240
268	Pirna	15.5	22002	16.8	23811	71.990	9567	23.55	10.665	7525	−15.457	18.25	1.45	2054	37.743	13.26	−3.54	−5016
269	Bautzen	18.7	35672	19.7	37327	136.510	10480	25.23	24.681	13026	34.403	18.31	−1.39	−2641	36.664	18.21	−1.49	−2815
270	Görlitz	21.1	18173	22.6	19159	32.040	2464	25.51	11.023	13003	47.943	18.25	−4.35	−3687	101.551	13.39	−9.21	−7810
271	Löbau-Zittau	20.4	15727	22.5	16899	67.650	3822	27.59	13.294	17700	56.367	18.26	−4.24	−3185	110.471	14.19	−8.31	−6241
	Variance (West)	5.15		4.40				6.78				3.50						
	Variance (East)	8.91		9.76				9.17				0.28						
	Variance (Germany)	26.42		27.29				50.08								17.32		

Column "Increment in unemployment rate" displays vector $\boldsymbol{y} - \boldsymbol{u}$, the predicted change of the actual $\boldsymbol{u}$nemployment rate after the redistribution of subsidies.

These rate increments converted from percent to the absolute number of unemployed are given in the auxiliary column "Increment in unemployed".

5. The last section, *Joint optimization* displays the results of unemployment equalization for East and West Germany processed jointly. The columns of this sections are the same as of Section *Separate equalization*.

6. Three bottom lines of Table 3.1 show the variance of the regional unemployment rates. These indices appear in graph titles.

3.3 Redistribution of aid

The redistribution of aid for attaining the optimal equalization of unemployment is illustrated by Figure 3.4 It depicts Table's 3.1 columns "Aid per one subsidized job", "Aid needed to reduce unemployment by 1%" (= vector $\boldsymbol{p}$), and "Redistribution of aid" (= vector $\boldsymbol{x} - \boldsymbol{a}$) both for separate and joint equalization.

The greatest redistribution takes place in East Germany, where the subsidies are far from being optimal. Most affected are large cities. For instance, Berlin has to return all subsidies back. Dresden, Magdeburg, Jena, Wismar, Schwerin, Rostock should receive at most half their actual grants. On the contrary, some other areas should receive an additional aid: Naumburg (277 Mio EURO), Stendal (179 Mio EURO), Bitterfeld (118 Mio), etc.

The optimization tries to reduce the highest unemployment by least expenditures. If the unemployment is rather high, the model subsidizes the region even at a higher price. If the unemployment is not much higher than the average but reducing it is affordable then the model 'gives a grant'. The last subsidized are the regions whose unemployment is close to the average and at the same time reducing it is too expensive.

For instance, consider Berlin. It has a large population, and reducing its unemployment by one percent requires subsidizing too many jobs, which makes this 'percent' much more expensive than in small regions. On the other hand, Berlin's net unemployment rate (with no subsidies) 18.7% is very close to the East German average ($18.7 - 18.21 = 0.49\%$), so that it makes little sense to give a subsidy. Berlin's actual unemployment 16.6% means that the subsidy (536 Mio EURO) received was not only unnecessary but also superfluous. Indeed, instead of fitting the unemployment to the average it results in $18.21 - 16.6 = 1.61\%$-deviation, which is three times more distant from the average than with no subsidies at all.

Besides the size of the region, the 'price' of 1%-decrement in unemployment is determined by the aid per one subsidized job. For instance, consider Naumburg with the 'price' of one job about 50 Ths EURO. Naumburg's unemployment 21.4% significantly deviates from the East German average 18.21%. Accordingly, it receives an additional subsidy, in spite of a high 'price' for 1%-decrement in unemployment. If Naumburg is considered within the whole of Germany, its influence on the variance is about 3/10 of its influence

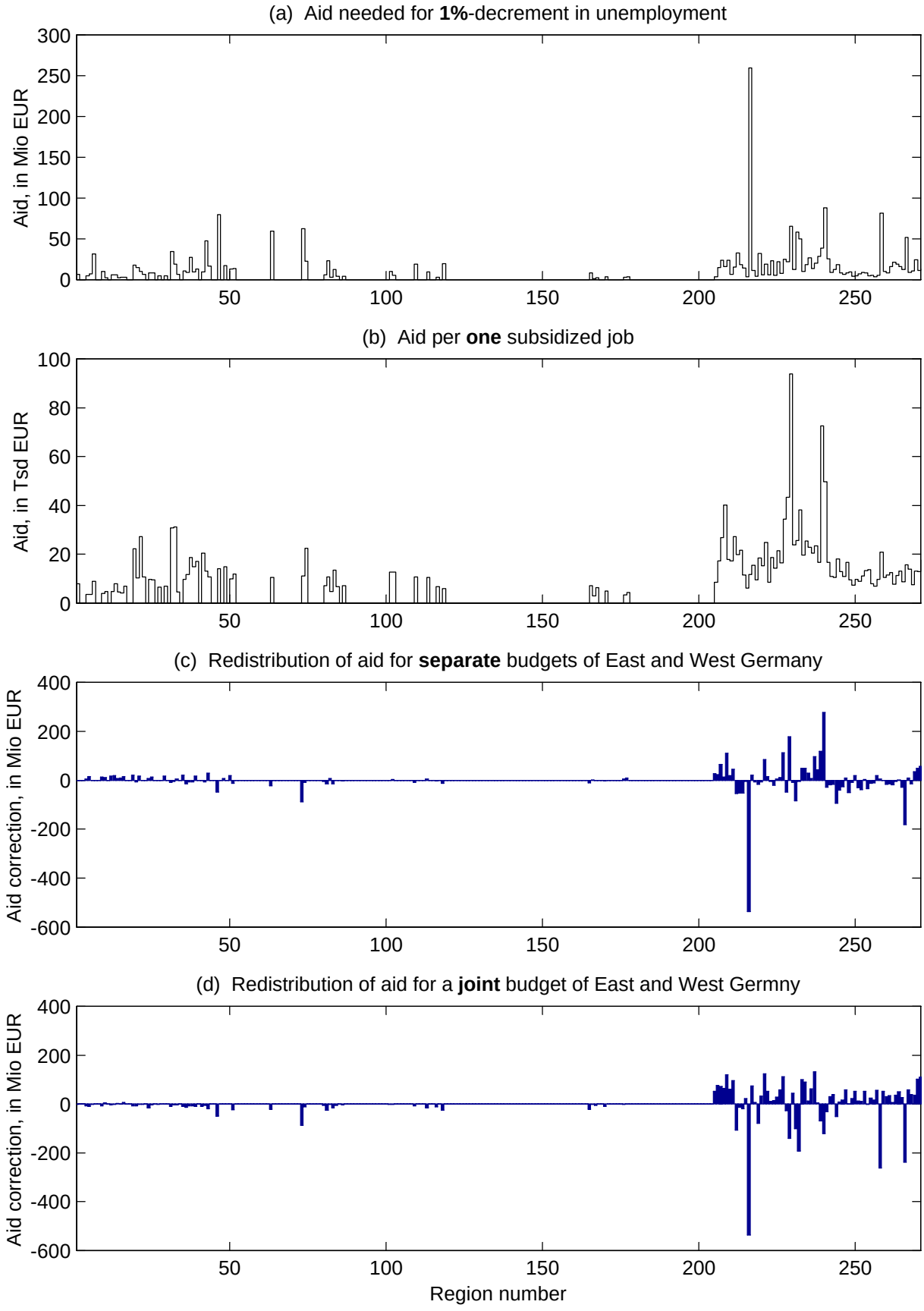


Figure 3.4: Redistribution of aid among German regions

within East Germany (1/217 against 1/67). This is deciding, and Naumburg looses its privilege and has to return the grant.

These and similar effects can be taken under control by certain weight coefficients. For instance, one may adjust the optimization process not to ignore large cities, or localities with expensive jobs like in ship-building.

3.4 Planning the budget for an equalization policy

Let us perform a kind of *sensitivity analysis* and investigate how the unemployment equalization depends on the budget. Figure 3.5 traces the effects of the equalization policy as a function of budget (a) for West Germany, (b) for East Germany, and (c) for the whole of Germany.

(a) Consider the top graph for West Germany. Its horizontal axis displays the variable budget. For several budget values, the regional unemployment is equalized. The resulted optimal average unemployment and variance are put into the table on the right hand. The corresponding table columns are depicted by dashed and solid *optimal curves* in the graph, respectively.

The actual (2002) average unemployment and variance are marked in the graph by asterisk * with the horizontal coordinate being the actual budget of West Germany 617.840 Mio EURO. Since neither the actual average unemployment, nor the actual variance are optimal, the corresponding marks are located above the optimal curves.

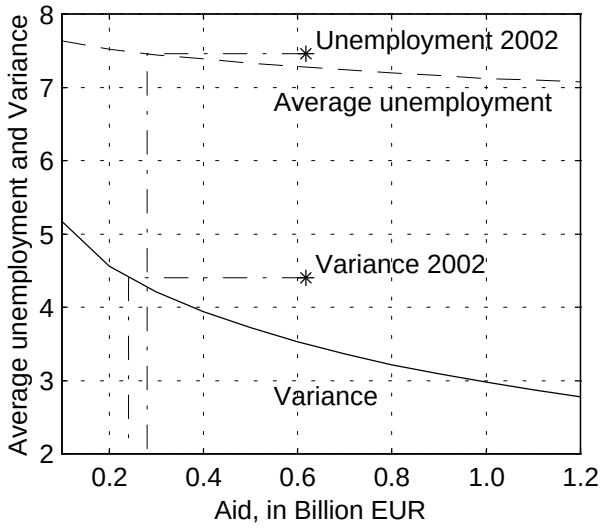
(b) The next graph for East Germany is similar. In particular, it visualizes the fact that the actual average unemployment is optimal: The corresponding mark is in the dashed curve. The variance is not optimal and lies significantly above the curve of optimal variance.

(c) For West Germany, the actual situation is not optimal either. The marks of actual average unemployment and variance lie above the optimal curves. Comparing with graph (b), graph (c) exhibits a much steeper decrease in the variance. This means that a joint budget might be quite efficient and could better equalize the situation in Germany than two separate budgets.

The curves and tables from Figure 3.5 enable us to predict the effect of an equalization policy with a certain budget. For instance, if we speak of West Germany and test a budget of 300 Mio EURO, then, under the optimal equalization, the predicted average regional unemployment is 7.44% and the variance 4.21. If we dispose a budget of 1 Bio EURO then the predicted average unemployment is 7.12% and the variance is 2.98. One can ask: Are we ready to pay additional 700 Mio for such a minor improvement?

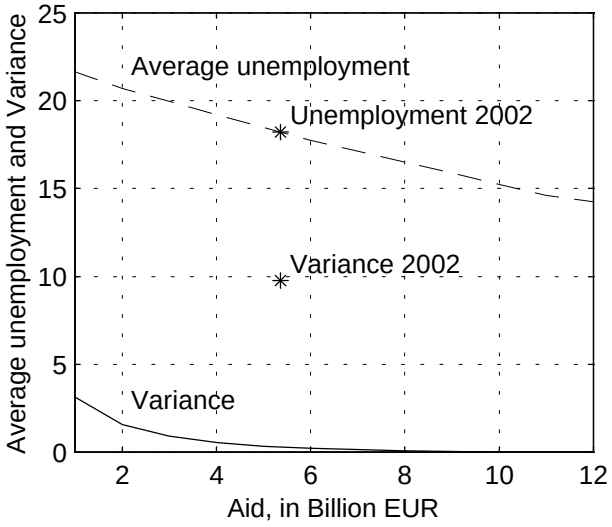
Using the curves and tables from Figure 3.5, one can answer similar questions and select the most appropriate equalization policy with the best 'quality-to-price ratio' (the understanding of which depends on the policy maker). Then the optimal distribution of the budget among all the eligible regions follows immediately from the main model.

(a) Equalizing unemployment in **West** Germany



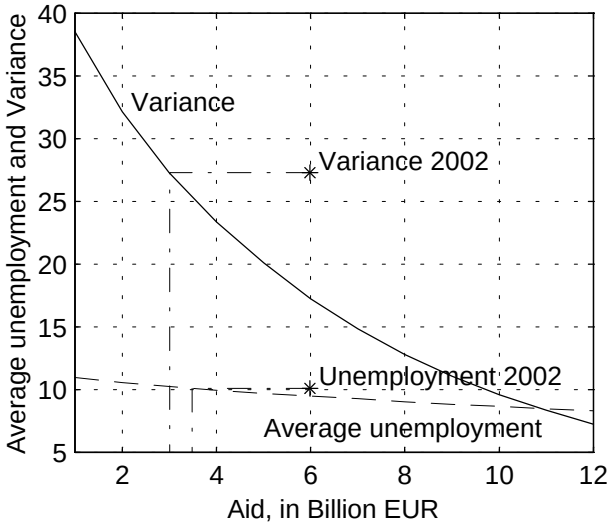
Aid, Mio EURO	Average unemployment %	Variance $\%^2$
100	7.63	5.17
200	7.52	4.56
300	7.44	4.21
400	7.39	3.94
500	7.33	3.72
600	7.29	3.53
700	7.24	3.36
800	7.20	3.22
900	7.16	3.09
1000	7.12	2.98
1100	7.10	2.87
1200	7.07	2.78

(b) Equalizing unemployment in **East** Germany



Aid, Mio EURO	Average unemployment %	Variance $\%^2$
1000	21.66	3.13
2000	20.70	1.58
3000	19.97	0.92
4000	19.22	0.55
5000	18.47	0.33
6000	17.75	0.21
7000	17.14	0.13
8000	16.51	0.08
9000	15.88	0.04
10000	15.24	0.02
11000	14.60	0.00
12000	14.26	0.00

(c) Equalizing unemployment in the **whole** of Germany



Aid, Mio EURO	Average unemployment %	Variance $\%^2$
1000	10.96	38.51
2000	10.56	32.13
3000	10.25	27.31
4000	9.97	23.37
5000	9.72	20.08
6000	9.49	17.26
7000	9.26	14.85
8000	9.04	12.81
9000	8.84	11.08
10000	8.65	9.61
11000	8.48	8.35
12000	8.33	7.24

Figure 3.5: Planning the budget of an unemployment equalization policy

3.5 Economic gain from the model

As shown previously, the model promises a better equalization of the regional unemployment than actually attained. It implies that the actual degree of equalization is attainable with a smaller budget. Say, the results obtained for 6 billion EURO can be obtained for 4 billion. Then the gain from the model is 2 billion.

Let us trace this train of thought with Figure 3.5. Consider the mark * *Variance 2002* in the upper graph (a) for West Germany. It indicates the actual state attained for 617 Mio EURO. Moving to the left along the dash-dot line, we retain the equalization level but reduce the budget. Attaining the optimal variance curve means that no further economy is possible. The necessary budget is to be found below, 240.901 Mio EURO. Starting from the mark * *Average unemployment 2002* and proceeding in the same way, we find the minimal budget for the actual average unemployment 7.45%, 280.737 Mio EURO.

The budget which suffices to retain both indices at the actual level is consequently the maximal of these two, 280.737 Mio EURO. We save 337.103 Mio. If we restrict attention to the variance only, as required by the equalization program, the minimal budget is 240.901 Mio, which saves 376.939 Mio. Then the average unemployment is 7.48% which is 0.03% higher than the actual one.

These steps are tabulated in Table 3.2. Its three rows provide the estimates of economic gain for West Germany, East Germany, and the whole Germany.

1. Consider the first row for West Germany.

   (a) The first section *State 2002* specifies the location of marks * in Figure 3.5. The underlying data are represented by the second graph in Figure 3.1.

   (b) The next section of Table 3.2 *Optimal equalization* displays the equalization result for the whole budget. The optimal indices, compared with the actual ones, indicate at a gain in quality. The underlying data are represented by the bottom graph in Figure 3.1.

   (c) Section *Economy equalization AV* answers to the question: How can the actual budget be reduced with retaining both *A*verage unemployment and *V*ariance at the actual level? This section specifies the intersection of dash-dot lines with the optimal curves in Figure 3.5.

   (d) The last section *Economy equalization V* is similar but restricts the attention to the *V*ariance only. It specifies the intersection of the dash-dot line through the mark * *Variance 2002* with the optimal variance curve in Figure 3.5.

2. For East Germany, the situation is rather curious.

   (a) If we take care of both average unemployment and variance (Section *Economy equalization AV*), no economy is possible (0 EURO). It is explained by the fact that the average unemployment under the optimal equalization coincides with the actual one (compare with Section *Actual equalization*).

   (b) If we take care of the variance only then no grant is necessary at all (Section *Economy equalization V*). Indeed, the natural self-regulation provides a better

Table 3.2:Economic gain from the unemployment equalization

	State 2002			Optimal equalization			Economy equalization AV				Economy equalization V			
	Average unemployment rate	Variance	Aid amount	Average unemployment rate	Variance	Aid amount	Average unemployment rate	Variance	Sufficient aid	Economy	Average unemployment rate	Variance	Sufficient aid	Economy
	%	$\%^2$	Mio EUR	%	$\%^2$	Mio EUR	%	$\%^2$	Mio EUR	Mio EUR	%	$\%^2$	Mio EUR	Mio EUR
West Germany	7.45	4.40	617.840	7.28	3.50	617.840	7.45	4.27	280.737	337.103	7.48	4.40	240.901	376.939
East Germany	18.21	9.76	5360.100	18.21	0.28	5360.100	18.21	0.28	5360.100	0.000	22.93	9.17	0.000	5360.100
Whole of Germany	10.11	27.29	5977.940	9.49	17.32	5977.940	10.11	25.30	3486.612	2491.328	10.25	27.29	3005.170	2972.770

variance than attained with the grant (see second and third graphs in Figure 3.2). Consequently, the total budget of 5360.100 Mio EURO can be saved.

3. The last row of Table 3.2 is similar, and exhibits the economy under both *Economy equalization AV* and *Economy equalization V* of order 2.5–3.0 billion EURO.

This efficiency estimate is certainly conditional. However, the order of economy comparable with the total budget is very unlikely due to the model inaccuracies only. It rather indicates at the really underused potential of the subsidies. Consequently, the situation can be improved by either making the grants work with a full efficiency, or by saving a considerable fraction of the grants.

Chapter 4

Conclusion

4.1 Further perspectives

A natural way of improving the model is explaining the regional unemployment as a function of subsidies (2.2) on the basis of longer control periods. It will improve the prediction accuracy of the model which is important for future planning.

Next, some more elaborated restrictions can be imposed, with regard to the size of localities, industries, and social factors.

Finally, some weight coefficients can be introduces into the model to reflect certain policy priorities.

The variance operator from Theorem 1 reduces computing the variance to a vector/matrix multiplication. This means that the restrictions and the prediction of the net unemployment can be arbitrarily complex, but if they are linear then the optimization problem is linear-quadratic and, consequently, solvable.

4.2 Recapitulation

1. The model developed contributes to equalizing the regional unemployment by optimally distributing the subsidies granted.
2. The difference between actual and optimized figures show that, most likely, the potential of active labor market policies is far from being exhausted.
3. In particular, it explains low efficiency of active labor market policies observed in empirical studies.
4. The methods suggested are aimed at the optimal use of European and national grants. Alternatively, policy goals can be attained with a more moderate budget, saving money for other purposes.
5. Econometric decision models of this type can be developed further to improve the performance of active labor market policies, implying socio-economical and political advantages.

Chapter 5

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